Status and ecology of the golden monkey (*Cercopithecus mitis kandti*) in Mgahinga Gorilla National Park, Uganda

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Abstract

Given the degree to which tropical ecosystems are currently being disturbed by human activities, it is essential to set priorities for conservation and thus it becomes important to consider how best to set these priorities. From this perspective, this study provides the first detailed investigations of *Cercopithecus mitis kandt*i, the golden monkey, focusing on the population in Mgahinga Gorilla National Park (MGNP), Uganda. Specifically, we (1) establish the current status of the golden monkey in terms of population size and distribution within the park in relation to vegetation types and altitude, and (2) investigate the golden monkey's feeding ecology. A total of 67 censuses of 4+ km transects were conducted along a cumulative distance of 299 km and 132 social groups were encountered. Densities were estimated to have increased by 1.6 times since a census 8 years ago, and the total population in the park is estimated to be between 3164 and 5059 individuals. The average size of golden monkey groups in MGNP is 30 individuals (range 3–62). This is similar to that of other subspecies in neighbouring forests. In contrast, the census conducted 8 years before estimated average group size to be eight individuals. Golden monkeys were observed to eat 21 plant species and they were inferred to eat an additional eleven from signs left behind and reports. Both study groups relied upon leaves (primarily young leaves), fruits and invertebrates for food, but the amount of time they fed on these different types of foods varied between the groups. Given the apparent increase in density since the census 8 years ago, the golden monkeys of MGNP appear to be doing well. However, given the number of snares and the extent of illegal extraction of bamboo found during the census, conservation efforts should be increased.

Key words: conservation, diet, endangered, home range, hybridization

Résumé

Etant donné la façon dont les écosystèmes tropicaux sont actuellement perturbés par les activités humaines, il est essentiel d'établir des priorités en matière de conservation et il est de plus en plus important de voir comment établir ces priorités. Dans cet esprit, cette étude rapporte les premières investigations détaillées menées sur *Cercopithecus mitis kandti*, le singe doré, dans la population qui vit dans le Parc National des Gorilles de Mgahinga (MGNP), en Ouganda. En particulier, (1) nous établissons le statut actuel du singe doré en termes de taille de la population et de distribution dans le parc, en fonction des types de végétation et de l'altitude, et (2) nous étudions les habitudes alimentaires du singe doré. Nous avons réalisé un total de 67 recensements le long de transects de plus de 4 km, sur une distance cumulée de 299 km ; nous avons rencontré 132 groupes sociaux. On estime que la densité a été multipliée par 1,6 depuis un recensement réalisé il y a 8 ans, et que la population totale du parc se situe entre 3164 et 5059 individus. La taille moyenne des groupes de singes dorés du Parc de Mgahinga est de 30 individus (elle varie de 3 à 62). Ce chiffre est semblable à celui des autres sous-espèces dans les forêts voisines. Par contre, le recensement effectué 8 ans plus tôt estimait la taille moyenne d'un groupe à 8 individus. On a observé que les singes dorés consommaient 21 espèces végétales et, en raison de signes qu'ils ont laissés et d'autres rapports, on croit qu'ils en mangent 11 de plus. Les deux groupes étudiés dépendaient de feuilles (surtout de jeunes feuilles), de fruits et d'invertébrés pour se nourrir, mais le temps qu'ils passaient à manger ces différents types

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de nourriture variait entre les groupes. Etant donné l'augmentation apparente de la densité depuis le recensement antérieur, il semble que les singes dorés du MGNP sont en bonne condition. Cependant, étant donné le nombre de lacets et l'étendue de l'extraction illégale de bambous constatée au cours de l'étude, il faut augmenter les efforts de conservation.

Introduction

There is little doubt that the threats posed to biological diversity by human modification of ecosystems are extensive (Chapman & Peres, 2001). Given the magnitude of these threats, it is essential to set priorities for conservation. Kaufman (in press) states that priority setting for species conservation requires a balance among three criteria. The first, phylogenetic uniqueness, stresses the importance of basal lineages (sometimes represented by one or a few extant taxa) that are threatened. The classic example is the New Zealand tuatara (*Sphenodon punctatus*), which is the only surviving representative of an ancient order of reptiles. A second criterion is functional or adaptive uniqueness. If a taxon has a particularly unique set of adaptations, they may represent the future potential for a larger taxonomic group to respond to environmental change and thus it should be considered of high priority. The third criterion, and the one most often adopted for legal purposes, is cladistic uniqueness, or in practical terms, the status of a taxon as a distinct species or subspecies. Once a taxon has been considered distinct, to evaluate its adaptive uniqueness, one must conduct detailed studies of its ecology to understand if it has unique adaptations that would potentially allow it to respond to ecosystem change, and determine the taxon abundance to know how seriously it is threatened.

The objective of this study was to conduct the first detailed investigation of *Cercopithecus mitis kandti*, the golden monkey, focusing on the population in Mgahinga Gorilla National Park (MGNP), Uganda. Specifically we aimed (1) to establish the current status of the golden monkey in terms of population size and distribution within the park in relation to vegetation types and altitude, and (2) to investigate the golden monkey's feeding ecology.

The genus *Cercopithecus* first appeared in the fossil record about 2.9 million years ago (Leakey, 1988). Their ancestors were probably semiterrestrial frugivores inhabiting woodland habitats. However, once they became rainforest specialists, their diversification became linked to the repeated isolation and divergence of populations occurring as a result of the recurring division of continuous forests into fragments associated with glacial/interglacial cycles (Chapman, 1984; Hamilton, 1988). It is estimated that in the last 2.3 million years there have been 20 such cycles (Hamilton, 1988). During isolation, populations of *Cercopithecus* species inhabited different fragments that would have differed in the selective pressures experienced. It is likely that the golden monkey diverged from an ancestral *C. mitis* during one of these isolation events.

The species *Cercopithecus mitis* has eight subspecies (Lernould, 1988), some of which have wide distributions (Haddow, 1956). Although *C. mitis*, as a species, is widespread and not threatened (Lawes, 1990), there are highly localized subspecies, some of which are endangered (Oates, 1996). For example the golden monkey is restricted to the Virunga volcanoes and to the Afromontane forests of Gishwati and Nyungwe in Rwanda (Haddow, 1956; Kingdon, 1971; Lernould, 1988). The golden monkey is considered an endangered subspecies. Despite its endangered status, little is known about the golden monkey's ecology and behaviour. Kingdon (1971) noted complications that arise in the classification of the blue monkey subspecies because of possible interbreeding among the subspecies around the Virunga volcanoes. Aveling (1984) only made incidental observations and Schaller (1964) suggested that bamboo formed the main component of their diet. Werikhe (1991) conducted a census in the then Gorilla Game Reserve of Mgahinga.

Methods

Study area

Mgahinga Gorilla National Park (MGNP), Uganda (33 km^2) encompasses the slopes of three volcanoes (Mgahinga 3474 m, Muhabura 4127 m and Sabinyo 3634 m) and is part of the greater Virunga Conservation Area (VCA), which covers 434 km^2 (Fig. 1). The park lies in the Albertine rift region, which is characterised by a high degree of avian and mammalian endemism (Bibby *et al.*, 1992) due to its proximity to the central refugium (Hamilton, 1988).

The vegetation types of the park are diverse and are broadly classified into three belts and several zones

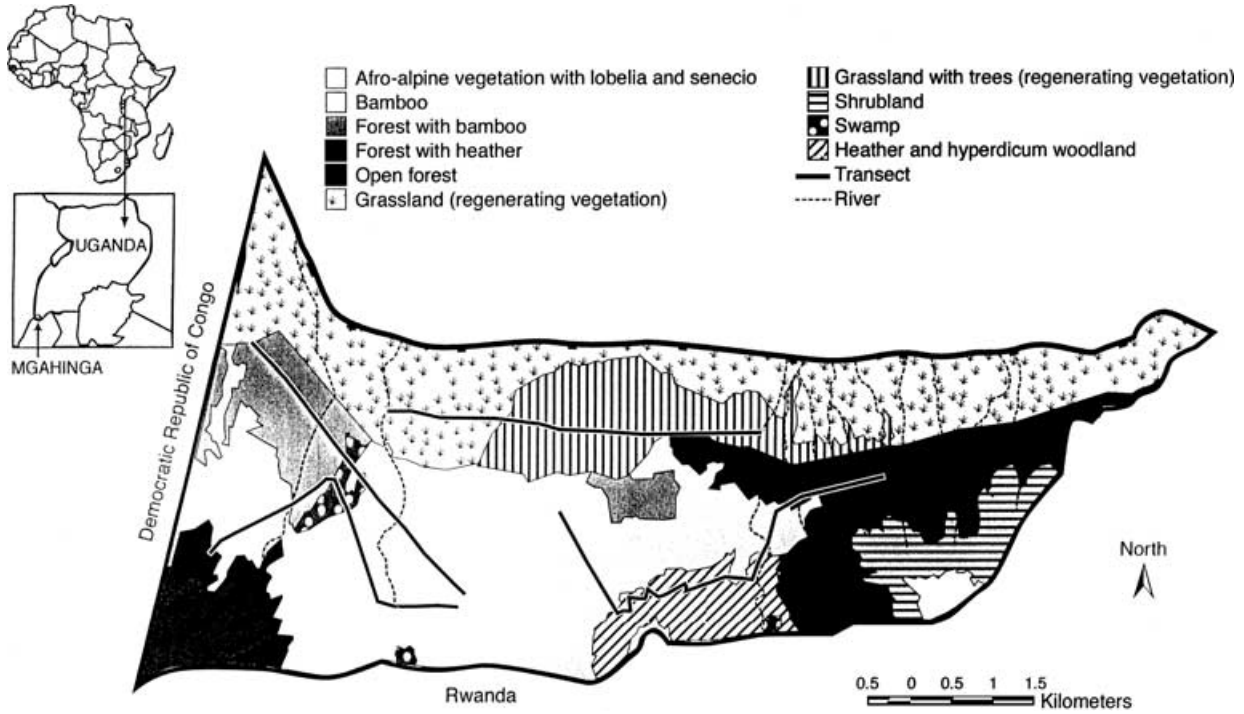

Fig 1 A map of Mgahinga Gorilla National Park, Uganda illustrating the major vegetation zones and the location of the transects used to census golden monkey (*Cercopithecus mitis kandti*)

within the belts (Fig. 1). The vegetation belts are alpine, subalpine (ericaceous) and montane forest (Schaller, 1963). The alpine belt is prominent at the highest altitude. The subalpine belt is composed of moorland, montane grassland and ericaceous zones. The moorland zone being transitional between the ericaceous zone and alpine belt. The ericaceous zone is characterised by the species *Philipa johnstonii, Erica arborea* and *Hypericum revolutum,* which are often densely laden with *Usnea* sp. lichens (Kalina, 1991). The montane forest belt is the most extensive vegetation type, encompassing 40% of the park and is characterized by low tree species diversity. Within this forest belt, the most extensive vegetation zone is bamboo. The rest of the park, approximately 33%, is covered by grassland and wooded grassland and was previously under cultivation (Fig. 1).

The area was declared a National Park in 1991. However, since being gazetted in 1930, the area has undergone a number of changes of name, status, size and management. These changes have had effects on the conservation of the area in terms of habitat degradation and poaching.

Table 1 The results of censusing four transects for golden monkey (*Cercopithecus mitis kandti*) in Mgahinga Gorilla National Park, Uganda (March to August 1998)

Transect	1	2	3	4
Length	4.0	4.0	4.0	5.7
No. of censuses	14	21	14	18
Total groups	7	51	31	43
Range	0–3	0–7	0–4	0–6
Mean + SE	0.5 ± 0.36	2.43 ± 0.26	2.21 ± 0.26	2.39 ± 0.22
95% confidence limit	0.38	0.83	0.82	0.73
% Precision	75.9	34.32	37.19	30.40
Groups per km	0.13	0.61	0.55	0.42

Line transect censuses and group counts

Line transect sampling has frequently been used to estimate animal abundance and has proven to be the desired method when estimating primate densities over large areas in a short period of time (Burnham, Anderson & Laake, 1980). A transect measuring at least 4 km (range

4.0–5.7 km) was established in each of four areas encompassing different vegetation types (Table 1). Censuses were conducted by walking at a rate of about 1 km h^{-1}. The variables recorded during censuses included location, sighting angle, sighting distance from the observer to first animal sighted, the perpendicular distance from the transect, height above the ground and vegetation type. All these measurements were related to the position at which the animal was first seen. The census walks were discontinued if there was an interruption of rain lasting more than 30 min or if rebels were encountered. Group counts were made on fifteen groups by *ad libitum* sampling. A successful count often took at least 3 h and depended on maintaining contact with a group until an opportunity arose to count the monkeys, such as when the whole group moved along a narrow path.

Observation of study groups

Two groups of golden monkeys, which had been reported by rangers to be partially habituated, were located and thereafter visited intermittently over a 2-month habituation period (January and February 1998). Subsequently, systematic instantaneous scan samples on feeding were conducted during day-long animal observations for 3 consecutive days each month for a period of 6 months. Four scan samples, each lasting 5 min, were conducted each hour on as many individuals as possible. The interval between scans was 10 min. Individuals were observed for 5–10 s and food items eaten were recorded. During a single 5 min sample period, a feeding observation by any individual on a particular food item was scored only once unless the same individual fed on different parts of the same food item. Group 1 (Ntebeko group) was followed for 19 days during which 69 h of observations were made. Group 2 (Gatalabana group) was followed for 17 days and 85 h of observations were made. Feeding observations were also recorded opportunistically. Secondary indications (e.g. discarded vegetative parts) were also used, as were interviews of rangers about the foods that they had observed the golden monkey eating.

Phenology monitoring and tree enumeration

Sixteen plant species, typically with ten individuals per species, were selected for monitoring, including food trees, common tree species and a vine. Monthly observations were made on the relative abundance of the different potential food items on individual plants. The levels of abundance were ranked on a scale of 0–4. Ten plots (25×29.5 m), spaced at least 50 m apart, were established along each of three transects: one in the forest with bamboo and two in the forest with heather/tree vegetation. All trees in the plots with d.b.h. (diameter at breast height) = 5 cm were enumerated. The d.b.h. = 5 cm was used because individual plants of *Galliniera coffeoides*, *Xymalos monosopora* and *Lepidotrichlia volkensii* on whose fruits golden monkeys fed, were observed to fruit at this size.

Data analysis

The maximum reliable sighting distance (MRSD) method (Chapman, Fedigan & Fedigan, 1988; Whitesides *et al.*, 1988) was used to determine the strip width sampled and to calculate the relative abundance of groups. Program 'Distance' was also applied to the data to estimate the relative density of groups (Laake *et al.*, 1994). Use of program 'Distance' requires perpendicular distances measured to the centre of a social group and these were determined through the trigonometrical relationship between sighting angles and distances of the first individual seen (Whitesides *et al.*, 1988). The centre of the group was regarded as half the mean of the typical group spread (Whitesides *et al.*, 1988).

Dietary diversity was assessed using the Shannon–Weiner (H^1) Index (Krebs, 1999). Proportions of food items in the diet were determined by dividing the number of feeding observations on a particular food item during one scan period by the total number of individuals feeding during that scan. Then the frequency values for each scan for the day were summed and divided by the total feeding scans for that day (Stoner, 1996). Stem densities (number ha^{-1}) and importance values of tree species enumerated were calculated and the similarity between different forests determined using Sorenson's index of diversity (Krebs, 1999).

Results

Abundance and distribution

A total of 67 censuses were conducted along a cumulated distance of 299 km and 132 groups were encountered. The average number of groups encountered per census ranged among transects from 0.50 ± 0.36 SE to

2.43 ± 0.26 SE, while sighting rates per kilometre ranged among transects from 0.13 groups km^{-1} to 0.61 groups km^{-1} (Table 1). The highest number of groups was sighted in the forest with bamboo (0.88 groups km^{-1}), while the lowest (0.13 groups km^{-1}) was in the regenerating zone (Table 2).

The density of golden monkeys in MGNP (using an MRSD of 40 m and 50 m) was estimated to be 5.11 groups km^{-2} and 4.25 groups km^{-2}, respectively. Werikhe (1991) reported the density to be 3.24 groups km^{-2} using a MRSD of 50 m. The density is higher, 6.03 groups km^{-2} and 4.34 groups km^{-2} at MRSD 40 m and 50 m, respectively, when only those areas that have not been encroached upon are considered. The density estimate obtained using program 'Distance' was 3.65 groups km^{-2} for the whole park and 4.24 groups km^{-2} for the unencroached zone.

Groups size ranged from three to 62 individuals and averaged 30 ± 6.06 SE animals per group ($n = 15$). Using this estimate of group size, the estimated density of golden monkeys varied from 153.3 individuals km^{-2} (MRSD 40 m) to 109.5 individuals km^{-2} (MRSD 50 m). Assuming the transects covered the vegetation types in proportion to their abundance in the park, the total population in the park is estimated to be between 3164 and 5059 individuals. If adjustments are made for the scarcity of animals in regenerating areas estimates would be between 2887 and 4106 individuals.

There were higher sighting rates and relative densities of golden monkeys in the bamboo zone and in forests with bamboo vegetation types. This suggests a preference by the golden monkeys for vegetation with bamboo as a major component. Altitudinal distribution of the golden monkey during this study ranged from 2450 m to 3284 m a.s.l. Groups at higher elevations were smaller and fewer. Groups were also fewer and smaller in the regenerating zone (Table 2).

Table 2 Sighting rates of golden monkey (*Cercopithecus mitis kandti*) groups in different vegetation types in Mgahinga Gorilla National Park, Uganda (March to August 1998)

Vegetation type	Length sampled (km)	Total groups	Total census distance (km)	Groups per km
Forest with bamboo	2.75	47	53.5	0.88
Swamp meadow	0.40	1	7.0	0.14
Pure bamboo	6.25	60	105.5	0.57
Heather-tree forest	1.90	7	33.4	0.21
Hypericum woodland	2.40	10	43.2	0.23
Regeneration zone	4.00	7	56.0	0.13

Table 3 Characteristics of forest types on different volcanoes of Mgahinga Gorilla National Park, Uganda (stem density = stems ≥ 5 cm d.b.h.; basal area = $m^2\ ha^{-1}$; food tree species include *Galliniera coffeoides, Nuxia congesta, Ilex mitis, Maesa lanceolata* and *Lepidotrichilia volkensii*)

	Forest with heather trees – Sabinyo	Forest with heather trees – Muhabura	Forest with bamboo Gatalabana
All trees			
Stem density	408.2	448.8	461.0
Basal area	30.4	25.7	26.5
Food tree species			
Stem density	89.5[a]	216.6[b]	139.7
Basal area	7.1	15.2	24.4

[a]Significantly different from Forest with heather trees – Muhabura and Forest with bamboo on Gatalabana. [b]Significantly different from Forest with bamboo on Gatalabana.

Results from tree enumerations showed that there was a high level of similarity in forest structure among forest types (Twinomugisha, 2000). There were also no significant differences in stem density and basal area ($m^2\ ha^{-1}$) among the different sample areas (Table 3). There were significant differences with respect to the abundance and basal area of food trees: the forest with heather at Sabinyo had fewer food trees and a smaller basal area of food trees than either the forest with heather trees at Muhabura or the forest with bamboo at Gatalabana (Table 3). Similarly, the stem density in the forest with heather at Muhabura was greater than the forest with bamboo at Gatalabana (Table 3). However, when importance values (IV) for individual food tree species were considered separately, differences were found among forest types that did not correlate with the distribution of golden monkeys. For example, *Maesa lanceolata* was poorly represented in the forest with bamboo in which most groups were sighted, yet it ranked first as a source of fruits for both the Ntebeko and Gatalabana golden monkey groups. A marked qualitative difference in undergrowth composition was noted between the vegetation types. In the bamboo and forest with bamboo zones, the undergrowth was composed of more herbs, shrubs and vines, some of which (e.g. *Cucumis acculeatus,*

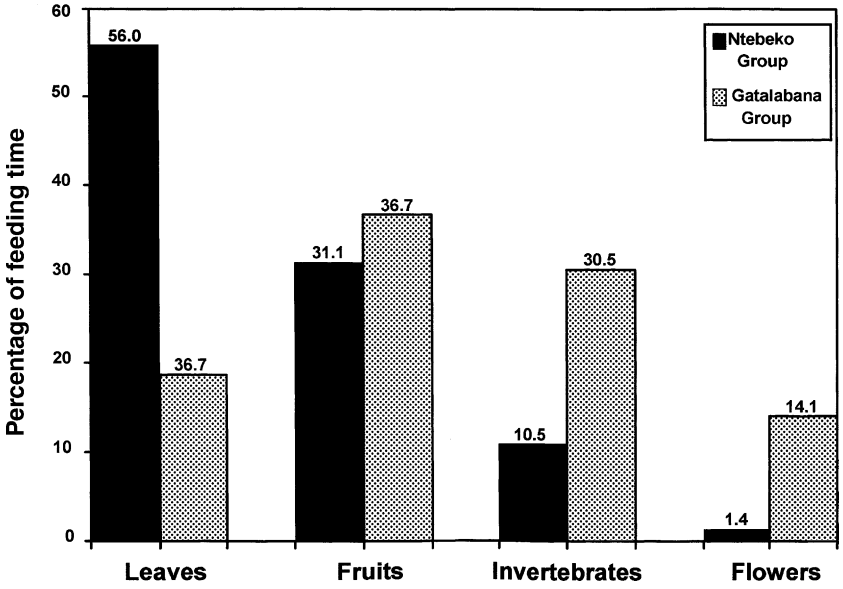

Fig 2 The food items in the diet of two groups of golden monkey (*Cercopithecus mitis kandti*) in Mgahinga Gorilla National Park, Uganda. The majority of the leaves that were eaten were young (47.4% Ntebeko group, 11.3% Gatalabana group)

Zehneria scabra) were observed to be eaten by the golden monkey.

Diet and temporal availability of food resources

Golden monkeys were observed to eat 21 plant species and they were inferred to eat an additional seven from signs left behind. Game rangers reported golden monkey to feed on five additional species. Fourteen of these plants were also eaten by the mountain gorilla. Both study groups relied upon leaves (primarily young leaves), fruits and invertebrates, but the amount of time they fed on these different types of foods varied between the groups (Fig. 2). The majority of feeding observations on vegetative items were on young parts (e.g. young leaves). The invertebrates eaten were mostly pupae of lepidopterous larvae, mostly picked from *Nuxia congesta* leaves.

The bulk of fruits in their diet were from *Maesa lanceolata*, *Urera hypselodedron* and *Galliniera coffeoides*. These three species fruited throughout the study period. Other fruit sources, such as *Lepidotrichlia volkensii* and *Ilex mitis*, were only available seasonally (Twinomugisha, 2000). Young leaves of *Ilex mitis* and *Nuxia congesta* peaked in abundance in March and this was the only time that the golden monkeys fed on the leaves of these two species.

The overall dietary diversity for the study groups was low and it did not differ between groups ($H^1 = 2.003$ for Gatalabana group and $H^1 = 1.723$ for the Ntebeko group, $t = 0.660$, df $= 35$, $P > 0.05$) and monthly diversity also exhibited an even and low trend.

Discussion

Status

The golden monkey population of MGNP appears to have increased by 1.6 times since Werikhe (1991) conducted his census 8 years ago. Given the inaccuracy of transect estimates and the fact that two different observers made each estimate, this increase should be viewed with caution. However, the increase may be related to improved protection of the area that has allowed vegetation to recover and has reduced further disturbance of the vegetation by local people and domestic animals. Despite these positive trends, golden monkeys are still threatened by various types of encroachment. During this study, we opportunistically removed 28 snares set to trap duikers (*Cephalophus nigrifronis* and *C. sylivicultor*) and bush buck (*Tragelaphus scriptus*). Golden monkeys are potential victims. Traps were found in all parts of the park, including higher elevations. Illegal bamboo collection still takes place, especially on the slopes of Mt. Mgahinga. In a single survey, several patches of cleared bamboo were found, totalling approximately 1 ha. Given the apparent increase in density since the study of Werikhe (1991), the golden

monkeys of MGNP appear to be doing well. The challenges for the future will be to ensure the continued health of the population. Given that golden monkeys are part of what draws tourists to MGNP, it may be appropriate to consider interventions that would increase the vegetation recovery rate of the regenerating forest (Chapman & Chapman, 1999).

The average size of golden monkey groups in MGNP was 30 individuals (range 3–62). The average size of blue monkey groups (*Cercopithecus mitis stuhlmanni*) in Kibale National Park is 24 individuals (Onderdonk & Chapman, 2000) and 33 in Kakamega Forest, Kenya (Cords, 1986). This comparison suggests that golden monkeys have a similar group size to close relatives in neighbouring forests. In stark contrast, Werikhe (1991) estimated the average size of golden monkey groups in MGNP to be eight individuals. It appears that there has been an increase in the average group size since Werikhe's census. Jiang *et al.* (1991) report an increase in rhesus monkey (*Macaca mulata*) average group sizes following the protection of the previously unprotected Nanwan Nature Reserve in China, where groups increased from 23 individuals to 60 within a period of 26 years. The study of Jiang *et al.* and ours suggest that when primate groups receive protection, the size of the groups initially increases, subsequently new groups may form.

During this study, three golden monkey coat colours were noted; one for females, one for males and an intermediate. Typically males have rufous-red on their back and on the dorsal part of their sides with some grizzled darker brown patches. The female colour is brighter and there is less grizzled brown. The intermediate coat colour, which appears to be a blend of these two patterns, involved two adult females in the Gatalabana group and one individual, thought to be an adult female, in a second group. These individuals could be hybrids between golden monkeys and some other guenon (*C. mitis doggetti* or *C. mitis schoutedenni*) as suggested by Kingdon (1971) or they could represent a coat colour polymorph within golden monkeys. Cases of coat colour polymorphisms have been reported in populations of some primate species whose patterns are otherwise stable (Booth, 1954; Hull, 1971). Hybrid coat colour patterns are intermediate between those of the parents, but can more closely reflect one parent than to the other. A likely candidate would be *C. m. doggetti* that was recorded in the park in the past by Kingdon (1971) and Werikhe (1991), but the number of *C. m. doggetti* sightings made by Werikhe was few. They were not seen during this study.

Diet of the golden monkey and distribution by vegetation type

The two groups of golden monkeys studied were observed to have little variation in their diet throughout the study and their diets were not diverse. Gautier-Hion (1988) noted that while guenons, in general, take a great variety of food items, a small number of items account for a great proportion of any single group's diet. For example, in her study of *C. ascanius schmidti* and *C. mitis stuhlmanni* in Kakamega Forest, Kenya, Cords (1986) observed that the top five foods accounted for 44–69% of the group's diet. At MGNP, the top five foods accounted for 81–85% of the golden monkey group's diet.

It has been suggested that when food density is low, diet will be diverse (Williamson, 1993). Thus, the low diversity observed in the diet of the golden monkey groups of Mgahinga coupled with the dietary overlap between the gorillas and golden monkeys, could indicate that food is abundant for the golden monkeys in MGNP. This speculation is supported by the increase in the size of the population since the study of Werikhe (1991).

The diets of the two study groups differed. For example, the amount of time the two groups fed on leaf material differed by 37.3%. In general, guenons show high levels of dietary flexibility with respect to the important components of their diet (Chapman *et al.*, 2002). Even within a given study area there may be large differences in the proportions of diet components between different social groups (Rudran, 1978a,b; Butynski, 1990; Chapman & Chapman, 2000). Given that dietary flexibility appears to be common in guenons, particularly in *C. mitis* (Chapman *et al.*, 2002), there does not appear to be anything unique about the foraging habits of golden monkeys.

The golden monkey population used bamboo forest and mixed forest/bamboo vegetation more than other vegetation types. The smaller range and lower levels of food abundance (Butynski, 1985; Werikhe, 1991), along with lack of shelter from extreme weather and predators, may account for lower density in the regenerating zone and at higher altitude. The other vegetation types in their decreasing order of importance to golden monkeys according to frequency of use are *Hypericum* woodland, forest with heather trees, swamp meadow and lastly

the regenerating zone. The high representation of *M. lanceolata* (which ranked first as a major fruit plant for the two study groups) in the forest with heather trees therefore did not highly influence the use of this zone relative to the bamboo and *Hypericum* woodland zones.

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